A remarkable new jellyfish (Cnidaria: Scyphozoa) from coastal Australia, representing a new suborder within the Rhizostomeae

Lisa-ann GERSHWIN
CSIRO Marine and Atmospheric Research, GPO Box 1538, Hobart, Tasmania 7000. Email: lisa.gershwin@stingeradvisor.com

Peter J.F. DAVIE
Queensland Museum, PO Box 3300, South Brisbane, Queensland 4101.

Citation: Gershwin, L. & Davie, P.J.F. 2013 06 30. A remarkable new jellyfish (Cnidaria: Scyphozoa) from coastal Australia, representing a new suborder within the Rhizostomeae. *Memoirs of the Queensland Museum — Nature* 56(2): 625–630. Brisbane. ISSN 0079–8835.

ABSTRACT

A new genus and species of rhizostome jellyfish, which cannot be placed in any known family or suborder, is described from central eastern Australia. The Ptychophorae suborder nov., can be separated from the two recognised suborders of the Rhizostomeae in having hooded rhopalia rather than open pits, unbranched evenly-spaced radial canals, and a large circular stomach. It also possesses a unique combination of some of the primary diagnostic characters of rhizostome families in both current suborders. Moreover, *Bazinga rieki* gen. nov., sp. nov. is unique among all rhizostomes in its very small mature size. It is probable that this species has been previously mistaken for juveniles of other species. ❑ *Scyphozoa, Rhizostomeae, Bazingidae, blubber jelly, new species, taxonomy.*

Rhizostome jellyfish are typically the most obvious of all gelatinous life-forms, often being large and brightly coloured, and often having bizarre exumbrellar morphology or conspicuous trailing clubs and filaments. Most rhizostomes are relatively large, and certain edible species support a significant commercial fishery. The biggest in the group is the infamous 2 m wide, 200 kilogram *Nemopilema nomurai* Kishinouye, 1922, which has been plaguing Japanese fishing grounds by the billions, particularly since 2000 (Kawahara *et al.* 2006). While there are a few rhizostomes in the 35–50 mm range, such a small size is exceptional.

The present work documents an intriguing little jellyfish that is particularly striking by reaching maturity at below 20 mm. It is also significantly different from other rhizostomes by its unusual combination of morphological characters, and by having a suite of unique features that have not otherwise been observed in any rhizostome family or suborder.

While *Bazinga rieki* gen. nov., sp. nov. is likely to be relatively common, it has probably been overlooked because its small size makes it easily mistaken for a juvenile of other species. In particular it is superficially similar to the common *Catostylus mosaicus* (Quoy & Gaimard, 1824), and similar sized juveniles of that species were also collected at the same time at one location.

MATERIALS AND METHODS

Specimens were fixed in a solution of about 5% concentrated formalin in seawater. Measurements were made on preserved specimens with digital calipers. Character evaluations were made on preserved specimens examined under a dissecting scope and from photographs and video of live specimens.

Peripheral portions of the radial canals were studied by dissecting away the subumbrellar circular muscles and exumbrellar warts.

All type material has been deposited in the Queensland Museum. Abbreviations: QM, Queensland Museum; BD, bell diameter; RC, radial canals.

SYSTEMATICS

Order RHIZOSTOMEAE Cuvier, 1799

Ptychophorae suborder nov.

Diagnosis. Body globular. Oral arms coalesced into a single short, ridged column; without scapulets. Rhopalia hooded, lacking typical pits. Velar lappets 4 per octant; 2 asymmetrical ocular lappets per octant. Annular muscles conspicuous. Subgenital ostia very small, round. Stomach circular, large. Radial canals 4 per octant, proximally unbranched, fluted; peripherally coalesced into vast open sinus with patchwork of jelly matrix.

Etymology. From the Greek *ptychos* (fold, leaf, layer) and *phoras* (bearing), in reference to the hooded rhopalia.

Bazingidae fam. nov.

Diagnosis. As for the suborder.

Bazinga gen. nov.

Type species. *Bazinga rieki* sp. nov. by present designation.

Diagnosis. As for the suborder.

Etymology. The name *Bazinga* has been conferred for two reasons. Firstly, *bazinga* is a slang term in present popular culture, meaning 'fooled you!' or 'stung you!' (e.g., the fictional Dr Sheldon Cooper in the television series *The Big Bang Theory*), and this is appropriate as the type species, *B. rieki*, is so small that it has probably been overlooked in the past as a juvenile of a larger species. Secondly, a seven-string harp is also called a *bazinga* (Cuppy 1950), and the straight radial canals of this new species are reminiscent of such strings.

Bazinga rieki sp. nov.

(Figs 1, 2)

Material examined. HOLOTYPE: QM-G331996, male (18.7 mm BD), Brunswick River, NSW, high tide in shallow water, Denis Riek, 04.12.2011.

PARATYPES: QM-G331997, male (15.5 mm BD), gravid female (14.0 mm BD), Cudgen Creek, Hastings Point, NSW, high tide, under road bridge, Denis Riek, 16.11.2011. QM-G331998, gravid female (16.4 mm BD), male (13.7 mm BD), Seagull Rocks, Brunswick Heads, NSW, rock pools, low tide, Denis Riek, 14.11.2011.

Description. Body thick, globular, rounded, tending to flattened above; small, reaching maturity at less than 20 mm BD (Fig. 1A). Exumbrella without any form of central hump or papillae clusters. Entire aboral surface evenly and densely covered in minute warts; each minute wart resembles small spherical sessile tag with yellowish core, possibly filled with zooxanthellae. Peripheral region of bell turned vertically downward parallel to body axis.

Oral arms (Fig. 1B) coalesced into single short column, ridged along column wall; arms formed into narrow folded sheets with mouthlets arranged along distal margin. Sheets contain scattered zooxanthellae throughout. Column wall and arm sheets finely granulated with many minute warts. Filaments, clubs, knobs, and other appendages lacking (Fig. 1F).

Subumbrellar surface (Fig. 1C) evenly covered with fine warts from oral arm column to just before edge of stomach; warts mostly longer proximally and rounder and smaller distally. Gastrogonadal cavity open to outside only at 4 small, round, perradial holes (Fig. 1D) located on subumbrellar portion of stomach wall very close to margin of stomach, about midway between oral arm column and proximal muscle bands. Circular muscle bands numbering about 12; in form of broad flat lamellae; richly impregnated with zooxanthellae.

Stomach circular in outline, large, occupying more than half body diameter; margin plainly visible through subumbrellar wall. Stomach extends via broad, evenly spaced, irregular flute-shaped radial canals, 4 per octant; peripherally coalesced into a broadly open circular sinus, punctuated with an irregular patchwork of jelly matrix (Fig. 2A). All radial canals arise at same level and are of same length. No radial canals reach bell margin, and no specifically differentiated rhopalial canal; radial canals dissipate in circular sinus. Proximal straight portions of canals clearly visible in live animal (Fig. 1E), but precise nature of peripheral gastrovascular system otherwise obscured by surface warting and subumbrellar muscle bands. Defined ring canal lacking.

Gonads comprised of heavily folded tissue sheets, plainly visible through subumbrellar wall as dark masses rich with zooxanthellae.

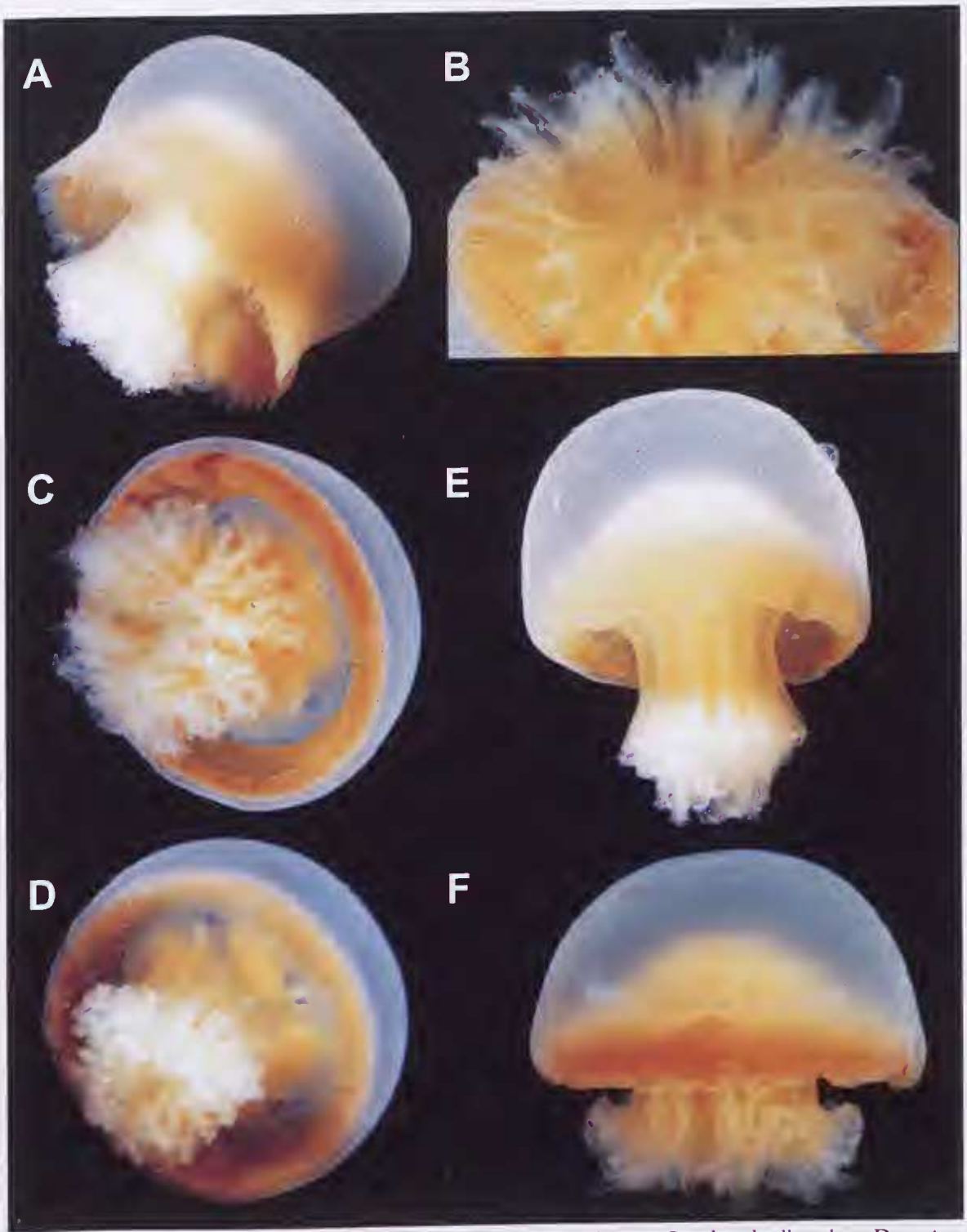

FIG. 1. *Bazinga rieki* gen. nov., sp. nov., in life. A, habitus; B, oral arms; C, subumbrellar view; D, gastrogonadal pores; E, bell on power stroke (note straight radial canals visible through bell); F, bell relaxed.

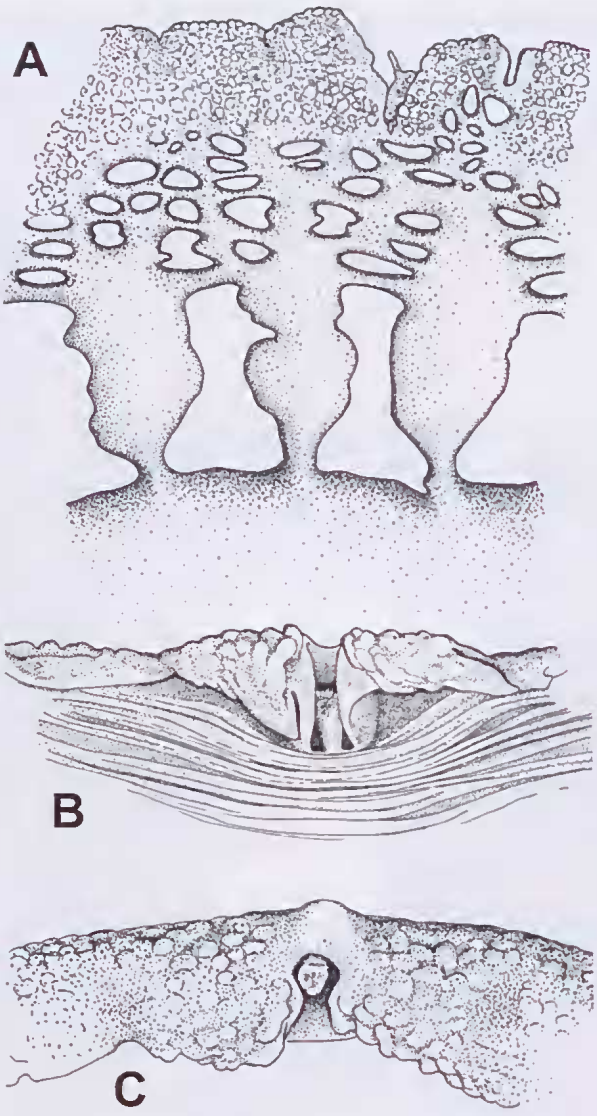

FIG. 2. *Bazinga rieki* gen. nov., sp. nov. **A**, peripheral canal sinus with subumbrellar muscles dissected away; **B**, subumbrellar view of rhopaliar niche (note asymmetrical lappets); **C**, exumbrellar view of rhopaliar niche (note protective hood in place of open pit).

Velar lappets 4 per octant, short, squared off, not as long as ocular lappets, defined from one another proximally by narrow region without warts. Ocular lappets two per octant, long and pointed, asymmetrical in preserved specimens, with right-hand lappets in ventral view folding to point obliquely along bell margin, left-hand lappets folding axially (Fig. 2B); bases of right and left ocular lappets folded axially to create a straight-sided gap between, slightly rounded marginally (Fig. 2C). All lappets heavily granulated with fine warts.

Rhopalia 8; 4 perradial and 4 interradial; deeply embedded under exumbrellar hood, in cavity formed by large fold on axial side of each ocular lappet (Figs 2B, C). Typical rhizostome exumbrellar smooth or radially ridged, rhopaliar pits lacking.

Colour in life. Bell jelly translucent and colourless; subumbrellar muscle folds golden brown due to zooxanthellae; gonads darker brown; after 2–3 months preserved in formalin solution, whole animal pale yellowish with brownish gonads.

Variation. Smaller paratypes have the radial canals in the shape of a simple broad straight line, without the flared sides of the holotype; mid-size specimens have the sides of the canals somewhat more divergent like a funnel.

Observations on live animals. Video taken by Denis Riek in both natural and laboratory settings accompanies the type series. The swimming pattern consists of continuous rapid pulsations at a rate of more than 200 per minute, and even though the bell is being continually flexed, there appears to be little effective propulsion. In an aquarium these pulsations were insufficient to lift it off the substrate. Thus it would seem that *Bazinga rieki* is largely at the mercy of currents.

Etymology. The species name, *rieki*, is to honour Mr Denis Riek, whose keen interest in photographing and identifying the sea-life of northern New South Wales led to the discovery of this most intriguing species.

Distribution. Bazinga *rieki* is only known from coastal waters off northern New South Wales. However, having been found at three different collecting sites on three different dates it seems likely to be relatively common, and could be expected to be found more widely along the central east Australian coast, particularly south of the Tropic of Capricorn.

DISCUSSION

The order Rhizostomeae was divided into two suborders by Stiasny (1921), based on a suite of structural features. Members of the Dactylio-

phorae are characterised by having radial folds on the surface of the rhopaliar pits; subgenital pits narrowed by conspicuous papillae; annular subumbrellar muscles; oral arms that are three-winged and may have scapulets; and by the anastomosing network of canals not being in communication with the gastric cavity.

In contrast, the Kolpophorae has smooth-surfaced rhopaliar pits; subgenital ostia without papillae; muscles variable in form from radial and straight to annular to feather-like arcs; anastomosing canals in communication with the gastric cavity; and oral arms that lack scapulets and are dichotomous, triangular, or three-winged. The primary diagnostic features for both suborders are summarised and compared in Table 1.

Bayha *et al.* (2010) constructed a phylogeny for the scyphozoan families using sequence data from 18S and 28S rDNA nuclear genes. Their results were largely consistent with prior morphological hypotheses, but importantly they concluded that the dactyliophorids were paraphyletic with respect to the kolpophorids. Since *Bazinga* falls well outside both of these groups morphologically, it seems likely that it is either the sister group to, or basal to, all other rhizostomes. Moreover, its hooded rhopalia are more reminiscent of some semaeostomes than of the rhizostomes, again suggesting a basal affinity. Obtaining DNA and testing these hypotheses should be considered a high research priority.

Rhizostomes are famously large, some reaching diameters of 350–500 mm or even more, and while there are a few small species in the size range 35–50 mm, e.g., *Cassiopea mdrosia* Agassiz & Mayer, 1899 (50 mm, Fiji), *Mastigias gracilis* (Vanhöffen, 1888) (35 mm, Red Sea), and *Acromitus tankahkeei* Light, 1924 (45 mm, China), this is unusual. However, *Bazinga rieki* is mature at less than 20 mm, making it by far the smallest rhizostome yet discovered. While this is noteworthy in itself, *Bazinga rieki* is also unique in its morphology, differing in major ways from all other rhizostomes.

The ocular lappets of *Bazinga rieki* are remarkable in being asymmetrically folded, and this is consistent across all specimens. Such an occurrence has apparently not been described in any other rhizostome.

The unusual canal system is also utterly unlike any other rhizostome, and can only be awkwardly described using standard terminology. In most rhizostomes, the radial canals arise at different levels along the cross-shaped stomach, with those arising from the interradii (i.e., the arms of the cross) being the shortest, those arising from the perradii (i.e., between the arms of the cross) being the longest, and those in between being midway in length. In *Bazinga* the arms are all the same length because they arise from the same level off the circular stomach. Moreover, rhizostomes are taxonomically separated based on a) how many radial canals extend past the ring canal to reach the margin, and b) whether the anastomosing network communicates with the stomach. However, *Bazinga* has no ring canal, and no radial canals extend to the margin, but rather, the coelenteric region covered by the circular muscles consists of a vast open sinus with scattered small patches of jelly matrix, giving the impression of a reversed meshwork, where the swollen and coalesced area of the anastomosed canals is far greater than the area between.

If one looks at individual families within the Rhizostomeae, irrespective of suborder, then *Bazinga rieki* does share some important characters with particular families. Like Cassiopeidae, the stomach of *Bazinga* is circular; however, in the only described cassiopeid genus, *Cassiopea*, it is very small compared to the whole diameter, whereas in *Bazinga* it is very broad, spanning more than half the bell diameter. *Bazinga* further differs from *Cassiopea* in all other primary diagnostic characters such as the number of rhopalia, the form of the subumbrellar muscles, the form of the oral arms, the form and number of the radial canals, and the general habits of the live animal.

Bazinga is reminiscent of Cepheidae in having small subgenital ostia; however, the Cepheidae is characterised by a large central dome on the exumbrella which often bears conspicuous papillae or sometimes a large knob. Even in *Cotylorhiza*, which lacks papillae or a knob, the central dome is well defined and dominates the bell. *Bazinga* has no such central dome; instead, the bell is globular and often somewhat flattened in life. Species in the Cepheidae are also characterised by having appendages on the oral arms such as filaments, stalked suckers, or spindles, whereas *Bazinga* completely lacks any

such appendages. Furthermore, the oral arms of *Bazinga* are coalesced whereas those of cepheids are not. Finally, the conspicuous annular muscles of *Bazinga* compared to the fine radial muscles of the cepheids, the circular stomach of the former compared with the octagonal stomach of the latter, and the completely different radial canal pattern between the two groups convincingly separates them.

Like some Kolpophorae families such as Mastigiidae, Versurigidae, and Thysanostomidae, *Bazinga* has well developed annular muscles on the subumbrella. However, along with many other structural features, the continuous subgenital porticus and separate oral arms of these other families would serve to immediately distinguish them from *Bazinga*.

Similarly, the Dactyliophorae families have annular muscles, but they have conspicuous papillae in the subgenital ostia, whereas *Bazinga* does not.

Even the families with coalesced oral arms would not be easily mistaken for *Bazinga*, with both the Rhizostomatidae and Stomolophidae also having scapulets, whereas *Bazinga* does not.

One of the key features that separates the two orders, Kolpophorae and Dactyliophorae, is the surface texture of the horseshoe-shaped rhopaliar pits, being smooth in the former and decorated by radial folds in the latter. However, the rhopalia of *Bazinga* are completely different, i.e., completely covered by an exumbrellar hood and embedded in a subumbrellar cavity formed by the folded lappets.

Therefore, while *Bazinga* does share some features with other Rhizostomeae suborders and families, its large circular stomach, unbranched evenly spaced radial canals, and hooded rhopalia are unique, and warrant new subordinal status. This decision is further reinforced by its unusual combination of other primary diagnostic characters such as coalesced oral arms and lack of scapulets and subgenital papillae, that also make it wholly unlike any other known family or suborder.

ACKNOWLEDGMENTS

We are indebted to Denis Riek for bringing this splendid little medusa to our attention. We sincerely thank Michelle Baker for her outstanding artwork, and Wolfgang Zeidler and Dale Calder for helping improve the manuscript in review. Travel costs for the senior author to visit the Queensland Museum were partially supported by travel grants from the Asperger's Services Australia and the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

LITERATURE CITED

Agassiz, A. & Mayer, A.G. 1899. Acalephs from the Fiji Islands. *Bulletin of the Museum of Comparative Zoology at Harvard University* **32**(9): 157–189, 17 pls.

Bayha, K.M., Dawson, M.N., Collins, A. G., Barbeitos, M.S., & Haddock, S.H.D. 2010. Evolutionary relationships among scyphozoan jellyfish families based on complete taxon sampling and phylogenetic analyses of 18S and 28S ribosomal DNA. *Integrative and Comparative Biology* **50**: 436–455.

Cuppy, W. 1950. *The Decline and Fall of Practically Everybody*. (Dorset Press: New York).

Cuvier, G. 1799. Sur l'organization de l'animal nommé méduse. *Journal de Physique, de Chemie, d'Histoire Naturelle et des Arts* **49**: 436–440.

Kawahara, M., Uye, S.-I., Ohtsu, K. & Iizumi. H. 2006. Unusual population explosion of the giant jellyfish *Nemopilema nomurai* (Scyphozoa: Rhizostomeae) in East Asian waters. *Marine Ecology Progress Series* **307**: 161–173.

Kishinouye, K. 1922. On a new rhizostome medusa. *Nemopilema nomurai* ng. nsp. *Dobutsugaku Zassi* **34**: 343–346. [In Japanese].

Kramp, P.L. 1961. Synopsis of the medusae of the world. *Journal of the Marine Biological Association of the United Kingdom* **40**: 1–469.

Light, S.F. 1924. A new species of scyphomedusan jellyfish in Chinese waters. *The China Journal of Science and Arts* 2(5): 449–450, 1 pl.

Mayer, A.G. 1910. *Medusae of the World. Vol. 3, The Scyphomedusae*. (Carnegie Institution: Washington)

Quoy, J.R.C. & Gaimard, J.P. 1824. *Voyage autour du monde ... executé sur l'Uranie et la Physicienne, pendant ... 1817–20. Zoologie. Voyage de l'Uranie. M. L. d. Freycinet*. Paris: 712 pp., plus Atlas.

Stiasny, G. 1921. Studien über Rhizostomeen. *Capita Zoologica* **1**(2): viii, 1–179, 5 plates.

1923. Das Gastrovascularsystem als Grundlage fur ein neues System der Rhizostomeen. *Zoologischer Anzeiger* **57**(9/13): 241–247.

Vanhöffen, E. 1888. Untersuchungen ueber Semaeostome und Rhizostome Medusen. *Bibliotheca zoologica Stuttgart* **1**(3): 51 pp., 6 pls., 1 map.